Nutritional status and food consumption in 10–11 year old Dutch boys (Dutch Nutrition Surveillance System)

BY GEERT VAN POPPEL, PETRA SCHNEIJDER, MICHIEL R. H. LÖWIK, JAAP SCHRIJVER AND FRANS J. KOK

TNO Toxicology and Nutrition Institute, PO Box 360, 3700 AJ Zeist, The Netherlands

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As part of the Dutch Nutrition Surveillance System, cardiovascular risk factors and food consumption (24 h recall) as well as haematological, Fe and vitamin status (A, B_6, C) were assessed in 126 Dutch boys aged 10–11 years (response 71%). Body mass index (BMI) and the sum of four skinfolds were strongly associated (r 0·85, $P < 0·01$) and 8% of the boys were overweight (BMI > 20·1 kg/m^2). Elevated serum total cholesterol levels (> 4·4 mmol/l) were observed in 38%; total cholesterol and low-density-lipoprotein-cholesterol levels were strongly associated (r 0·88, $P < 0·001$). Intake of fat was high (38% of energy) and too much fat was saturated (polyunsaturated:saturated 0·44, guideline: 0·5–1·0), whereas intake of carbohydrate (49% of energy) and dietary fibre was low. About 12% of the boys had insufficient Fe stores (plasma ferritin < 12·0 μg/l) and the mean Fe intake (9·0 mg/d) was below recommended daily allowance (10·0 mg/d). Plasma ferritin was, however, not associated with haematological indices and no frank anaemias were observed. No marginal values were observed for vitamins A, B_6 and C status. In conclusion, the main nutritional risks in boys aged 10–11 years are cardiovascular risk factors and Fe nutrition.

Nutrition surveillance: Children: Cholesterol: Vitamins: Iron

An adequate nutritional status is considered to be especially important in children, as it is required for optimal growth and development. In industrialized societies, nutrition-related disorders such as cardiovascular diseases are primarily regarded to be problems of overnutrition. Borderline nutritional deficiencies may, however, occur when the nutrient density of the diet is low (Arab *et al.* 1982). Since little is known about the prevalence of such borderline deficiencies in children, an evaluation of the nutritional status of children is required. From a prevention point of view it is also important to establish the cardiovascular risk profile at an early age. Within the framework of the Dutch Nutrition Surveillance System (Löwik & Hermus, 1988) we, therefore, determined cardiovascular risk factors, assessed food consumption, and evaluated the haematological, Fe and vitamin status in a sample of 126 10 to 11-year-old Dutch boys.

POPULATION AND METHODS

In 1987, parents of all seventh grade boys in sixteen schools in the district East-Gelderland, the Netherlands, were approached for written consent. Of those approached, 138 boys (response 71%) participated. Children beyond age 10·0–11·5 years and non-Caucasians were not included in the analysis (n 12).

Anthropometry

Body weight (Statmoss bascule) was recorded to the nearest 0·1 kg and body height (Stanley Extender spring rule) to the nearest 0·01 m. Weight and height were measured after the subject had removed shoes and upper clothing. Body mass index (BMI) was calculated as weight (kg) divided by the square of body height (m). Systolic (Korotkov phase I) and diastolic (Korotkov phase V) blood pressures were measured in duplicate in mmHg after a 5 min sitting rest using a Random Zero Sphygmomanometer. Using a Holtain skinfold caliper, skinfold measurements (biceps, triceps, suprailiac, subscapula) were recorded to the nearest 0·2 mm.

Haematology and biochemistry

In 108 boys, non-fasted blood samples were taken by venapuncture using evacuated tubes (Venoject). One sample was taken without anti-coagulant and the serum was separated. Another sample was taken with EDTA as an anti-coagulant and stored under vacuum at 4° for 17–23 h. Part of this sample was used for the isolation of plasma and erythrocytes (Schrijver *et al.* 1982), the remainder was used for whole-blood analysis. The following analyses were performed in whole blood, plasma, erythrocytes and serum.

Whole blood. Vitamin C was assessed as L-ascorbic acid + dehydro-L-ascorbic acid (Speek *et al.* 1984) directly after opening the evacuated tube. We observed that this overnight (dark) storage of vacuum Venoject tubes results in vitamin C values less than 5% below values determined directly after venapuncture. Haemoglobin (Hb), packed cell volume (PCV) and erythrocyte count (RBC) were measured using an Ortho ELT8. From these values, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and mean corpuscular haemoglobin concentration (MCHC) were calculated.

Plasma. Vitamin A was estimated as *all-trans* retinol (Fankel, 1978). Total carotenoids (Speek *et al.* 1986) and ferritin (Miles *et al.* 1974) were determined, while vitamin B_6 was estimated as pyridoxal 5′-phosphate (PLP) (Chabner & Livingstone, 1970).

Erythrocytes. The in vitro aspartate aminotransferase (EC 2.6.1.1) activation coefficient (EAST-AC) was determined (Stanulovic *et al.* 1967).

Serum. Percentage Fe saturation (Fuhr, 1965) and total cholesterol, low-density-lipoprotein (LDL)- and high-density-lipoprotein (HDL)-cholesterol (Boehringer Mannheim Gmbh Diagnostica: CHOD-PAP method, cat. no. 237574; Testcombination HDL-Cholesterol, cat. no. 400971; LDL-cholesterol (PVS method) cat. no. 726270) were determined.

Vitamin C values from one run (*n* 8) and haematology results from two runs (*n* 15) were omitted because of deviations from the laboratory protocol.

Reference values

Internationally accepted reference values have been used for systolic and diastolic blood pressure (Report of the Second Task Force on Blood Pressure Control in Children, 1987), Hb and MCHC (World Health Organization, 1972) and retinol (World Health Organization, 1982).

The age- and sex-specific 97 percentile according to Rolland-Cachera *et al.* (1982) has been used to assess the prevalence of obesity based on the BMI. Van der Haar & Kromhout (1978) considered children to be frankly obese if their sum of four skinfolds exceeded 52 mm, which corresponds with 25% body fat according to Parizkova & Roth (1972).

Cut-off values for serum cholesterol have been taken from the US Cholesterol Consensus Conference (National Institutes of Health Consensus Development, 1985). Plasma cholesterol values have been converted to serum values using a conversion factor 1·036 (Laboratory Methods Committee of the Lipid Research Clinics Program of the National Heart, Lung and Blood Institute, Bethesda, 1977). Reference values have been taken from Christakis (1973) for PCV, from Dacie & Lewis (1984) for RBC and MCH, from Dallman *et al.* (1980) for ferritin and Fe saturation, from O'Neal *et al.* (1970) for carotenoids, and from Sauberlich *et al.* (1976) for vitamin C. Cut-off points for PLP and EAST-AC are based

Table 1. *Obesity indices and cardiovascular risk factors in 10–11 year old Dutch boys*
(Mean values and standard deviations for 126 boys)

	Mean	SD	Percentiles 10th	Percentiles 50th	Percentiles 90th	Percentage different from reference value
Body mass index (kg/m^2)	17·0	2·1	14·9	16·6	19·4	8 > 20·1
Triceps skinfold (mm)	11·0	5·2	6·0	9·6	18·3	—
Sum of four skinfolds* (mm)	34·3	17·5	18·8	28·6	60·3	14 > 52
Diastolic blood pressure (mmHg)	68	9	57	67	80	0 > 90
Systolic blood pressure (mmHg)	115	9	103	113	127	0 > 140
Serum total cholesterol† (mmol/l)	4·3	0·6	3·7	4·2	5·0	38 > 4·4
Serum HDL-cholesterol† (mmol/l)	1·35	0·25	1·02	1·30	1·72	—
Serum LDL-cholesterol† (mmol/l)	2·65	0·56	1·94	2·62	3·31	—

HDL, high-density-lipoprotein; LDL, low-density-lipoprotein.
* Biceps, triceps, subscapula, suprailiac.
† *n* 108.

on the 2·5 percentile of blood donors aged 18–65 years (Schrijver *et al.* 1985) who were healthy according to the criteria of the Dutch Red Cross.

Food consumption

During a home visit (*n* 123), the child was questioned about the food intake of the previous day. During this 24 h recall (Baranowski *et al.* 1986) the mother was present and provided additional information. Recipes and household measures were ascertained. Intake of energy and nutrients was calculated using the Dutch food composition table, version 1986 (Nevo Table, 1986). Recommended daily allowances (RDA) (Voedingsraad, 1989) and the guidelines for a healthy diet (Richtlijnen Goede Voeding, 1986) as established by the Netherlands Nutrition Council were used to evaluate dietary intake.

Statistical analysis

Statistics have been calculated using the BMDP package (BMDP, 1983). Relationships between nutritional status indicators have been assessed by univariate linear regression analysis. Correlations are Pearson correlation coefficients. Skewness of frequency distributions was established by standard BMDP procedures. Skewed frequency distributions were logarithmically transformed before regression analysis.

RESULTS

The mean age of the boys was 10·8 (SD 0·3) years, mean body length 1·46 (SD 0·07) m, and mean body-weight 36·5 (SD 6·2) kg. Values for obesity and cardiovascular risk factors are given in Table 1. BMI and the logarithm of the sum of four skinfolds were strongly positively associated (Fig 1). Based on a BMI > 20·1, 8% of the children were overweight, and 38% had elevated serum cholesterol levels (4·4 mmol/l). LDL-cholesterol and total cholesterol levels were strongly positively associated (*r* 0·88); $P < 0·001$), whereas HDL-cholesterol and total cholesterol showed a somewhat weaker positive association (*r* 0·38; $P < 0·001$). HDL-cholesterol:total cholesterol (mean 0·32 (SD 0·06)), however, was negatively associated with total cholesterol levels whereas LDL-cholesterol:total cholesterol (mean 0·62 (SD 0·07)) was positively associated with total cholesterol levels (Figs. 2 and 3).

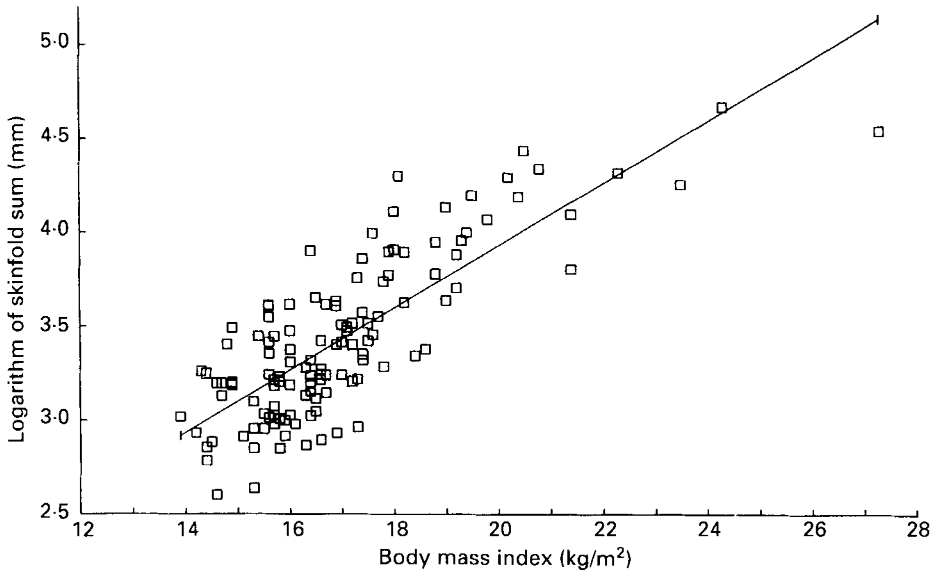

Fig. 1. Body mass index and sum of four skinfolds in 125 10–11-year-old Dutch boys, $y = 0{\cdot}61 + 0{\cdot}17x$, r 0·81, $P < 0{\cdot}001$.

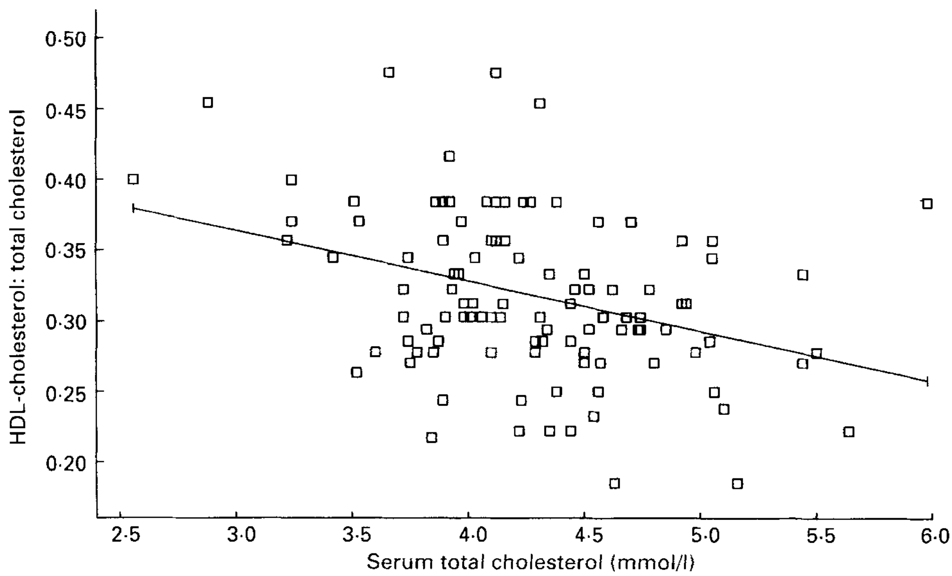

Fig. 2. Serum total cholesterol and the ratio high-density lipoprotein (HDL)-cholesterol:total cholesterol in 108 10–11-year-old Dutch boys, $y = 0{\cdot}47 - 0{\cdot}035x$, $r - 0{\cdot}35$, $P < 0{\cdot}001$.

Results for haematology and Fe and vitamin status are given in Table 2. One boy had an Hb $< 7{\cdot}5$ mmol/l and plasma Fe saturation below 10%. Insufficient Fe stores (ferritin $< 12{\cdot}0$ μg/l) were assessed in 12% of the boys. No significant correlations were assessed between ferritin values or percentage Fe saturation and haematological indices (all $r < 0{\cdot}17$ and $P > 0{\cdot}1$). Ferritin and percentage Fe saturation were not correlated (r 0·04, $P = 0{\cdot}76$). No associations were observed between plasma PLP and EAST-AC (r 0·08, $P = 0{\cdot}41$) or between plasma total carotenoids and plasma retinol (r 0·05, $P = 0{\cdot}58$).

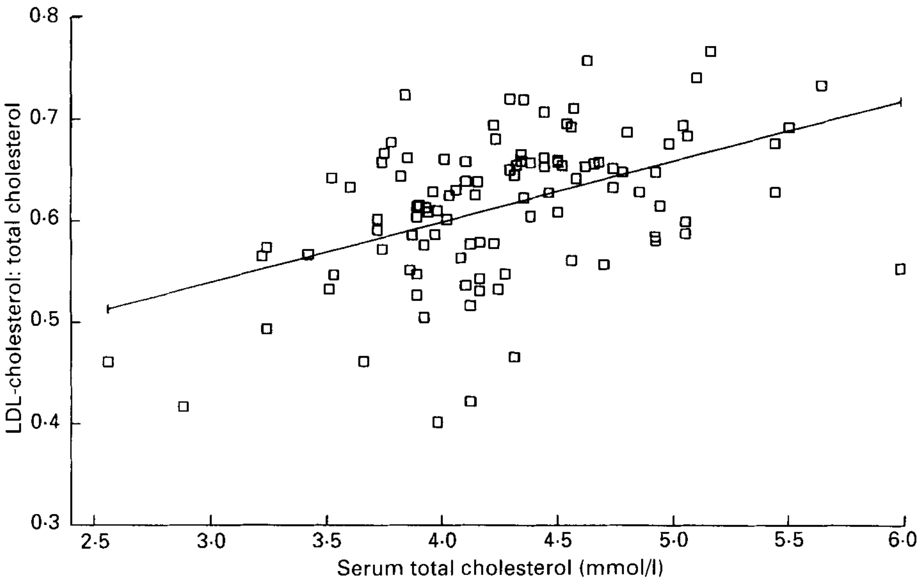

Fig. 3. Serum total cholesterol and the low-density lipoprotein (LDL)-cholesterol: total cholesterol ratio in 106 10–11-year-old Dutch boys, $y = 0{\cdot}36 + 0{\cdot}060x$, r 0·47, $P < 0{\cdot}001$.

Table 2. *Haematological, iron and vitamin status variables in 10–11 year old boys*

(Mean values and standard deviations for 108 boys)

	Mean	SD	Percentiles 10th	Percentiles 50th	Percentiles 90th	Percentage different from reference
RBC* (10^{12}/l)	4·6	0·3	4·2	4·6	5·0	0 < 4·0
Haemoglobin* (mmol/l)	8·4	0·4	7·8	8·3	8·9	1 < 7·5
Packed cell volume (%)	42	2	39	42	44	0 < 36
MCV* (fl)	91	4	86	91	95	0 < 76
MCH* (fmol)	1·82	0·08	1·7	1·71	1·82	0 < 1·49
MCHC* (mmol/l)	20·0	0·5	19·3	19·9	20·7	2 < 19·2
Erythrocyte AST-AC	1·90	0·16	1·71	1·88	2·15	1 > 2·28
Plasma PLP (nmol/l)	52·9	19·3	33·0	50·0	76·0	0 < 20
Blood ascorbic acid† (μmol/l)	47·6	11·7	30·7	47·7	61·0	1 < 17
Plasma carotenoids (μmol/l)	1·7	0·6	1·0	1·6	2·4	2 < 0·70
Plasma retinol (μmol/l)	1·0	0·2	0·8	1·0	1·2	0 < 0·7
Plasma ferritin (μg/l)	18·6	1·9	11·0	16·0	29·0	12 < 12·0
Serum Fe saturation (%)	29·1	8·3	19·4	29·5	40·8	1 < 10

RBC, erythrocytes; MCV, mean corpuscular volume; MCH, mean corpuscular haemoglobin; MCHC, mean corpuscular haemoglobin concentration; PLP, pyridoxal 5′-phosphate; AST-AC, aspartate aminotransferase (*EC* 2.6.1.1) activation coefficient (Stanulovic *et al.* 1967).

* *n* 93.

† *n* 100.

Food consumption values are given in Table 3. Compared with the guidelines for a healthy diet, intake of fat was high and too much of it was saturated, whereas intake of carbohydrate and fibre were low. The mean intakes of Fe, vitamin A and vitamin B_6 were below RDA: the mean intake of the other micronutrients met or exceeded RDA.

Table 3. *Daily nutrient and energy intake in Dutch boys aged 10–11 years*
(Mean values and standard deviations for 123 boys)

	Mean	SD	RDA
Energy (MJ)	8·8	2·1	9·5
Protein (g)	67·5	20·4	61
Carbohydrate (%)	49·2	7·2	55
Fat (%)	38·0	6·6	30–35
P:S ratio	0·44	0·19	0·5–1·0
Cholesterol (mg/MJ)	25	11	< 33
Fibre (g/MJ)	2·5	0·8	> 3
Calcium (g)	1·03	0·48	0·90–1·20
Iron (mg)	9·0	3·2	10
Vitamin A (mg)	0·75	0·46	1·00
Thiamin (mg)	0·93	0·36	0·90
Riboflavin (mg)	1·48	0·60	1·20
Pyridoxin (mg)	1·21	0·45	1·30
Vitamin C (mg)	71	60	55

RDA, Recommended Daily Allowances (Voedingsraad, 1989) and Guidelines for a Healthy Diet (Richtlijnen Goede Voeding, 1986).
P:S ratio, polyunsaturated:saturated fat ratio.

DISCUSSION

Anthropometry and cardiovascular risk factors

The mean BMI in the present study was lower than the mean value in the prevalence study of the Lipid Research Clinics (1979), but similar to the median value of age-specific references (Rolland-Cachera, 1982). Triceps skinfolds in our study are again smaller than values in the Lipid Research Clinics (1979), but are comparable with Dutch reference values (De Wit *et al.* 1984). However, the sum of skinfolds in our study is somewhat higher than reference values (P_{50} 24·5) reported by De Wit *et al.* (1984) and mean values reported in three Dutch populations by Van der Haar & Kromhout (1978). Though interobserver differences in skinfold measurements (De Wit *et al.* 1984) may partly explain this difference, our results suggest that body fatness of the boys in our sample is higher than among previously studied Dutch boys.

Cut-off values for obesity, whether based on BMI or on skinfold measurement are somewhat arbitrary. Skinfold measurements estimate body fatness (Parizkova & Roth, 1972), whereas BMI does not establish whether or not overweight is due to fat (Garrow, 1981). Our results show a high correlation between the BMI and the sum of four skinfolds, which indicates that a high BMI refers to a high body fatness. Therefore, a substantial proportion of the children can be considered obese. This is unfavourable, as obesity in childhood might predispose to adult obesity (Garn, 1986). Despite the rather high prevalence of obesity in the study group, energy intake was slightly below RDA (Table 3; RDA for moderately active boys). The 24 h recall method used in this study may, however, have underestimated dietary intake as compared to the dietary history method (Bingham *et al.* 1988). Moreover, the adequacy of energy intake is difficult to evaluate as information on physical activity was lacking in our study.

Based on serum total cholesterol, 38% of the boys may be considered to be at risk of cardiovascular disease (> 4·4 mmol/l). Mean serum total-, HDL- and LDL-cholesterol levels are similar to those reported by Lipid Research Clinics (1979). Total cholesterol levels are, however, lower than values previously reported among Dutch boys (Van der Haar & Kromhout, 1978; Kromhout *et al.* 1981). Our study was performed in one specific region in the Netherlands. Genetic factors may influence plasma cholesterol levels and obesity indices. However, it is not likely that regional differences in genetic make-up have biased our results, as a previous nation-wide survey among Dutch elderly did not observe regional differences in cholesterol levels or obesity indices (Löwik *et al.* 1987). Our results, thus, are in accordance with the suggestion of a downward trend (Kromhout *et al.* 1981; Knuiman & Katan, 1985) for serum cholesterol levels in the Netherlands.

The observed strong relationship between serum total cholesterol and LDL-cholesterol and the somewhat weaker association between total cholesterol and HDL-cholesterol are due partly to autocorrelations as both HDL and LDL are fractions of total cholesterol. With increasing total cholesterol levels, however, the HDL-:total cholesterol ratio decreases, whereas LDL-:total cholesterol increases. This observation is in accordance with other studies (Cresenta *et al.* 1982) and indicates that elevated cholesterol levels in our population are mainly due to high levels of atherogenic LDL-cholesterol, rather than HDL-cholesterol.

In this study we were not able to investigate associations between nutrient intakes and plasma cholesterol levels, as the 24 h recall methodology in a study of this size is inadequate to reveal such associations. Nevertheless, the food consumption data in our survey (Table 3) suggest that high blood cholesterol levels may be nutritional in origin as intake of fat is high and too much fat is saturated, whereas intake of carbohydrate and fibre are low. In comparison with previous Dutch studies (Van der Haar & Kromhout, 1978) however, our results suggest that in recent years fat intake in Dutch boys has slightly decreased whereas polyunsaturated fat:saturated fat has increased.

Haematological, Fe and vitamin status

The haematological values given in Table 2 show that virtually no anaemias were present among the boys studied. Nevertheless, insufficient Fe stores (plasma ferritin $< 12{\cdot}0$ μg/l) were observed in 12% of the boys. In accordance, the mean dietary intake of Fe was found to be substantially below RDA (Table 3). Fe depletion is considered to result first in low ferritin levels, indicating insufficient Fe stores (Cook & Finch, 1979; Expert Scientific Working Group, 1985). As Fe stores become more exhausted, the percentage Fe saturation drops, and finally circulating haemoglobin levels drop. Since we found no correlations between ferritin values, Fe saturation and Hb levels, decreased Fe stores in some of the boys appeared not to have resulted in decreased Hb-synthesis anaemia. Boys aged 10–years are, however, just before the adolescent growth spurt, and sufficient Fe stores are of special importance as the growth spurt induces strongly increased requirements of Fe (Dalman *et al.* 1980).

Intake of pyridoxine is below the Dutch RDA (1300 μg/d). However, both plasma PLP levels and EAST-AC values do not indicate a marginal vitamin B_6 status in these children in comparison with healthy adult blood donors. This comparison seems warranted, as the EAST-AC values in children probably do not differ from those of adults (Sauberlich *et al.* 1970). Moreover, we did not observe an association between plasma PLP levels and EAST-AC values, which would be expected if some of the boys had an insufficient vitamin B_6 intake. The vitamin B_6 status in the study group is therefore considered to be adequate.

The mean intake of vitamin A in this group of boys was also below RDA. Here again, however, both plasma retinol and plasma carotenoid levels do not indicate a marginal vitamin A status which is, therefore, considered to be adequate in this group of boys.

The mean intakes of calcium, riboflavin and thiamin met RDA values so their intake can be considered to be sufficient in this group of children. Dietary intake values for vitamin C also met RDA. In accordance blood vitamin C levels, which are affected by recent intake, also indicate an adequate supply of this vitamin.

Conclusion

The main nutritional risks in these 10–11 year old Dutch boys relate to cardiovascular risk factors, as cholesterol levels and (saturated) fat intake were generally high. Furthermore, Fe nutrition is of special concern, as both Fe intake and Fe stores were frequently low. The intake of the other micronutrients studied was adequate.

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